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ABSTRACT

Biosocial influences on sex differences, found for school achievement test results in grades 3 and 6, have been studied by means of opposite-sex twin pairs and singleton controls, attending the same classes as the twins. As expected the opposite-sex twin pairs tend to be more similar in achievement test results in Swedish and mathematics than their controls. This is, however, more pronounced for Swedish and could probably be due to mathematics being more susceptible to the type of training experienced at school, while achievement in the Swedish subject is more dependent upon both home background and heredity-environment interaction. Both the twins and their controls tend to become less similar within pairs in achievement test results from grade 3 to 6. It does not seem, thus, as if the educational impact experienced by twins or non-twins, attending the same classes, will make them more similar in this respect. It is also evident that the increasing sex differentiation between grades is not primarily due to home background influences, but rather can be explained both by differential educational treatment and differentiation of abilities with increasing age. (Author)

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BIOSOCIAL INFLUENCES ON SEX DIFFERENCES IN SCHOOL ACHIEVEMENT

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Biosocial Influences on Sex Differences
in School Achievement

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Summary

Biosocial influences on sex differences found for school achievement test results in grades 3 and 6 have been studied by means of opposite-sex twin pairs and singleton controls. Specifically the environmental impact of class affiliation from grade 3 to 6 is discussed.

Several other investigations have found sex differences for test results in Swedish and Mathematics. Girls tend to have higher average scores on Swedish tests and boys on the Mathematics tests. These differences also tend to increase with age. There are also results suggesting that boys and girls tend to rely on different cognitive skills when solving mathematical problems.

This would indicate that the magnitude of sex differences would vary with different types of Mathematics tests. The present investigation also shows a fluctuation in the magnitude of the sex differences with larger differences for mental arithmetic and problem solving in comparison to numerical operations. The largest sex differences for the Swedish tests were found in favour of girls for punctuation, arrangement and spelling. There was also a trend for increasing sex differences from grade 3 to 6 in Mathematics, which is consistent with results from previous studies.

Biosocial influences on the above-mentioned sex differences have been studied by means of intra-pair correlations. Such correlations have been calculated for opposite-sex twin pairs and boy-girl pairs of singleton controls, matched for age and attending the same classes as the twins.

Approximately 40 twin pairs and 20 (due to missing data) control pairs have been followed from grade 3 to 6 in the Swedish comprehensive school. They have attended the same classes and thus been exposed to the "same" educational impact during this period. The tests used have been devised to equalize marks and contain samples of items representing the content of a particular subject area. Follow-up data have been collected for the Mathematics tests, while Swedish test results only are available in grade 3. The twins and their controls are included in an extensive Swedish longitudinal twin study, called the SLU-project. Results for the like-sex SLU-twin pairs and their controls have been presented in several previous articles.

As expected the opposite-sex twin pairs tend to be more similar in achievement test results than their controls for most of the tests in Swedish and Mathematics. This is, however, more pronounced for the Swedish subject, where the controls show virtually no similarity, while the twins show a substantial correlation. This could probably be due to Mathematics being more susceptible to the type of training experienced at school, while Swedish is more dependent on both home background and heredity-environment interaction. This interpretation is also in agreement with results from earlier twin studies.

For Mathematics there are also larger differences between subtests than for Swedish. In mental arithmetic, for instance, the twins do not seem to be more similar than the controls. This result, of course, tends to imply that the type of ability measured by this test, and the obtained sex difference, are largely effects of sex differentation interacting with school training.

The intra-pair correlations tend to decrease for both the twins and the controls between grade 3 and 6. It does not seem, thus, as if the educational impact experienced by twins or non-twins, attending the same class, will make them more similar during this period. This result is also in concordance with previous like-sex twin comparisons and can be explained both by differential treatment and differentiation of abilities with increasing age.

Opposite-sex twin pairs as a means of studying biosocial influences on sex differences have not been much used. This, however, could be a way to separate hereditary and home background influences from effects of sex differentiation and educational impact by comparisons with singleton controls. The longitudinal data available in this study make the comparisons even more valuable, since it will be possible to investigate long-term effects.

BIOSOCIAL INFLUENCES ON SEX DIFFERENCES IN SCHOOL ACHIEVEMENT

Introduction

In Sweden standardized achievement tests are used in the compulsory school system to equalize marks. The tests are optional and have mostly been given in the third, sixth and eight grades. The test items have been randomly chosen from essential parts of the curriculum.

Several investigations have found sex differences for test results in Swedish and Mathematics. Girls tend to have higher average scores on the Swedish tests and boys on the Mathematics tests (Svensson, 1971). The differences, however, seem to be more pronounced for the boys on the Mathematics tests (Ljung, 1965; Wernersson, 1977; Westin-Lindgren, 1979). It also seems as though sex differences at least in mathematics increase with age (Husén, 1967; Fischbein, 1976; Ljung, op.cit.).

Maccoby & Jacklin (1974) found in an overview of sex differences on different types of tests that girls above the age of eleven frequently do better on verbal tests. Sex differences in favour of the boys on tests of quantitative ability generally tend to appear around the age range 9-13 years. After this age boys move ahead, although there is great variation in the degree of male advantage reported. It, thus, seems as though differences in scholastic achievement between boys and girls tend to increase at puberty.

Maccoby & Jacklin (op.cit.) also discuss the magnitude of sex differences on different types of mathematical tests. They conclude that "evidently there are different ways to attack mathematical problems, and individuals differ in the cognitive skills they characteristically bring to bear on such problems". This means that sex differences would vary, for instance, with the possibility to rely on verbal skills on different types of mathe-

matical tests. Wittig and Petersen (1979) also point out that several studies found smaller sex differences in mathematical achievement when controlling for spatial ability.

A plausible hypothesis would be, therefore, that the more you can rely on spatial ability to solve mathematical problems, it would favour the boys and the more you can rely on verbal ability it would favour the girls (Fennema, 1974). Husén (1967) found, however, that boys had better results on mathematical items with a verbal content compared to pure numerical items. If there are distinctive sex differences in mathematics achievement per se is therefore an open question.

There are also studies indicating that type of verbal content is related to sex differences in achievement (Coffman, 1961; Tyler, 1976; Stage 1979). "Person-oriented" words seem to be easier for women, while "object-oriented" words seem to be easier for men. This means that it would be possible to construct verbal tests specifically "made" for women or men respectively.

A much debated question has been the role played by the school in increasing sex differences in achievement. Many studies have found a differential treatment of boys and girls in the classroom, and they have also often reported the teachers to be quite unaware of this (Katz et al., 1977; Lobban, 1978; Swedmark, 1981; Einarsson, 1982; Sutherland, 1981). The sex difference in school achievement can therefore not just be explained by innate differences, home background influences or differential course taking (Benbow & Stanley, 1980).

Wernersson (1977) found, for instance, in her survey of studies concerning school influences on sex differences in achievement, that they tend to increase for male subjects such as mathematics and decrease for female subjects with a predominant verbal content. Her conclusion is that "behavioral sex differences are enhanced and underlined at school even if they are not created there" (op.cit. pp. 136-137). It thus seems as though existing

behavioral differences between boys and girls and not the educational structure or the teachers' sex role stereotypes in themselves, create differential sex treatment in the classroom. The teachers are, however, according to Wernersson's interpretation, prone to adjust to these differences instead of trying to decrease the variation in these respects.

There are few studies, however, trying to specifically study the interaction of biological and school treatment factors (Morgan, 1979). Coles (1980) has for instance made a survey of genetic explanations of reading and learning problems and he points out that educational experiences is an area insufficiently examined in these types of studies.

Three different aspects on sex differences in school achievement have been stressed here. The first one is *age* where the research results tend to show increasing sex differences with age.

The second aspect is *content* with boys showing an advantage in mathematical and spatial achievement and girls in verbal achievement. With increasing age the female advantage seems to become smaller and the male larger, however. The third aspect is *treatment* and specifically formal schooling.

Sex differences in school achievement could of course *both* be an effect of hereditary and home environment influences *and* of sex differentiation interacting with educational treatment in the classroom. One method to separate these effects is to compare opposite-sex twin pairs and control pairs of boys and girls attending the same classes. This could be done for different types of tests to explore the *content* effect and over time to study both *age* and *treatment* effects.

A plausible hypothesis would be that a subject specifically trained at school such as Mathematics would show a more similar within-pair variation for twins and controls, compared to Swedish, that tends to be more susceptible to hereditary and home environmental

effects (Fischbein, op.cit.). Certain parts of Swedish or Mathematics, such as for instance spelling or punctuation and mental arithmetic, could be suspected to be more specifically trained at school and therefore show smaller differences between the twin and the control group.

Concerning age and treatment effects over a time span, earlier studies have shown a tendency to greater differentation of abilities with increasing age (Ljung, op.cit.), which would then be evident for both twins and controls.

The differential treatment of boys and girls reported by many researchers would also point in a similar direction.

Materials and methods

In 1964 a longitudinal study of physical and mental growth in twins and controls of matched age (the SLU-project) started at the Department of Educational Research at the Stockholm School of Education. The data presented in this paper have been collected in the SLU-study. The twins were taken from the 40 largest cities and towns in Sweden and their controls were attending the same classes as the twins. Originally the sample consisted of 94 pairs of monozygotic (MZ) twins, 133 dizygotic (DZ) pairs of the same sex, 96 dizygotic (DZ) pairs of different sex, and 1.194 controls. There were no separated twin pairs included in the study, so the twins in a pair were brought up in the same home and usually also attended the same classes at school.

For every twin pair, control pupils in the same classes as the twins were included in the study. The controls were of the same sex as the twins and approximately of the same age. The data collection has been more complete for the twins, however, who were followed through school irrespective of change of classes or schools, whereas this was not the case for the controls. This means that data could be missing for one or both of the control pupils, which sometimes makes comparisons difficult.

The twins and their controls were followed through school from grades 3 to 9 and different kinds of measurements were collected: physical growth data (eg. height and weight measurements), school achievement and ability test results, self ratings, ratings by others, and socioeconomic data.

Physical growth data and intelligence test results for the opposite-sex twins have been reported elsewhere (Fischbein, 1981; 1983). School achievement test results for the opposite-sex twins and their controls attending the same classes are presented here to investigate specifically eductional treatment effects on sex differences. This has been done by means of intraclass correlation coefficients calculated for opposite-sex twins (DZ-OS) and controls (CO). The coefficients show the magnitude of within-pair variance relative to between-pair variance. The formula used is

$$R = \frac{V_{bp} - V_{wp}}{V_{bp} + V_{wp}}$$

where R = intraclass coefficient, V_{bp} = variance between pairs, and V_{wp} = variance within pairs. (For a more detailed discussion of this method and for a description of the data program used for computing, see Ljung, 1966.)

The school achievement tests used consist of five tests in Swedish given in grade 3, three tests in Mathematics given in grade 3 and five tests in Mathematics given in grade 6. The five Swedish tests were "reading rate", "alphabetic order", "arrangement", "punctuation" and "spelling". The three Mathematics tests used in grade 3 were "numerical operations", "mental arithmetic" and "problem solving I". In grade 6 these same three tests were given and in addition to these "geometry" and another type of "problem solving II" test, presenting new information on the basis of which the pupils can deduce a solution. (A thourough description of the standardized tests used in the Swedish school system to equalize marks has been given by Ljung, 1965.)

Results

Table 1 presents means and standard deviations for the different sub-tests in Swedish and Mathematics for boys and girls separately. The male group consists of both twin boys in the opposite-sex pairs and male singleton controls. The female group correspondingly consists of the twin girls in opposite-sex pairs and the female controls.

Table 1. Achievement test results for boys and girls

	Boys			Girls			
Test	M	SD	N	M	SD	N	z
Grade 3							
Reading rate	49.12	9.92	286	50.70	9.71	250	-2.07*
Alphabetic order	49.77	10.15	294	50.66	9.48	253	-1.07
Arrangement	49.06	9.74	293	51.95	10.23	252	-3.40***
Punctuation	48.96	10.06	291	51.71	9.14	249	-3.35***
Spelling	49.05	9.83	292	51.54	10.29	253	-2.89**
Swedish Total	48.92	7.36	282	50.98	7.05	244	-3.32***
Numerical oper.	50.67	9.96	296	50.09	10.12	268	0.69
Mental arith.	52.15	10.61	299	48.93	9.31	268	3.87***
Problem solv. I	51.04	9.94	295	50.13	10.01	265	1.08
Math. Total	50.93	8.95	290	49.39	8.47	263	2.10*
Grade 6							
Numerical oper.	51.75	10.14	269	50.18	9.49	289	1.89
Mental arith.	52.37	10.26	265	48.88	9.72	285	4.25***
Problem solv. I	52.14	10.77	263	49.38	9.43	278	3.17**
Geometry	51.91	10.30	265	49.81	9.63	280	2.47*
Problem solv. II	51.08	10.37	264	50.34	9.71	276	0.86
Math. Total	51.48	8.62	258	49.44	7.81	266	2.87**

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

In Swedish there is only one test "alphabetic order" showing no significant differences between boys and girls. For all the other tests in Swedish the girls have a significantly higher average achievement than the boys.

In Mathematics the difference between boys and girls, with a higher average for the former, tends to increase from grade 3 to 6. There is only one test "numerical operations" showing no significant sex difference in favour of the boys in either grade. For the two additional tests in grade 6 that were not given in grade 3, the boys have a higher significant mean in "geometry" but not in the deduction type of "problem solving II".

In table 2 analysis of variance results of achievement test scores for opposite-sex twins (DZ-OS) and boy-girl controls (CO), attending the same classes in both grade 3 and 6, are presented. The tests showing no significant sex differences (table 1), "alphabetic order", "numerical operations" and "problem solving II", have not been included.

Table 2. Analysis of variance of achievement test results for DZ-OS and CO

Test	DZ-OS No. of pairs	V_{bp}	V_{wp}	F	R	CO No. of pairs	V_{bp}	V_{wp}	F	R
Grade 3										
Reading rate	34	158.46	60.40	2.62	.45	36	97.36	85.57	1.14	.06
Arrangement	35	128.03	70.24	1.82	.29	36	112.86	77.72	1.45	.18
Punctuation	35	150.01	68.10	2.20	.38	36	114.79	67.31	1.71	.26
Spelling	35	122.45	87.19	1.40	.17	37	104.97	77.93	1.35	.15
Swedish Total	34	84.35	34.53	2.44	.42	34	57.47	36.41	1.58	.22
Mental arith.	38	113.54	50.17	2.26	.39	38	141.53	72.54	1.95	.32
Problem solv. I	37	175.14	59.89	2.92	.49	37	127.43	43.08	2.96	.50
Math. Total	36	111.27	35.58	3.13	.52	37	99.45	37.45	2.66	.45
Grade 6										
Mental arith.	38	104.12	78.80	1.32	.14	22	148.01	68.46	2.16	.37
Problem solv. I	37	146.97	61.27	2.40	.41	23	150.35	77.76	1.93	.32
Geometry	37	140.16	85.01	1.65	.25	23	115.71	99.46	1.16	.08
Math. Total	37	101.32	39.18	2.59	.44	22	81.32	45.05	1.81	.29

As can be seen from table 2 the number of pairs for the twin and control pairs are approximately the same in grade 3. In grade 6, however, more control than twin pairs are missing. This is due to the difficulty mentioned earlier of following the controls, when they are moving to another class. This has of course to be taken into consideration in validating the results for grade 6. A comparison of test results for controls with complete and missing data is presented in table 3.

Table 3. Achievement test results for controls with complete data and with data only in grade 3

	Results in grade 3 and 6			Results in grade 3 only				
Test	M	SD	N	M	SD	N	Diff.	t
Reading rate	51.77	10.00	26	51.23	9.84	40	0.54	0.21
Alphabetic order	54.00	9.54	27	50.24	10.30	41	3.76	1.54
Arrangement	50.59	10.81	27	49.90	8.98	41	0.69	0.27
Punctuation	51.65	7.65	26	47.45	10.62	42	4.20	1.89
Spelling	53.07	9.08	27	50.67	9.99	42	2.40	1.03
Swedish Total	51.69	7.20	26	49.87	6.74	39	1.82	1.02
Numerical oper.	51.81	8.07	32	49.31	9.51	42	2.50	1.22
Mental arith.	53.28	9.54	32	51.45	10.87	42	1.83	0.77
Problem solv. I	51.53	9.93	32	49.17	8.59	42	2.36	1.07
Math. Total	51.84	8.00	32	49.67	8.41	42	2.17	1.13

A comparison of table 2 and 3 gives the impression that around 15 pairs are missing in grade 6 (22 pairs instead of 37) but around 21 pairs with missing data are included in table 3 (42 pupils). This inconsistency is due to the fact that of the 22 pairs having data in grade 6 some are missing in grade 3. The group is thus not strictly longitudinal.

The group with missing data in table 3 tends to have somewhat lower means on all tests compared to the group with complete data. There are, however, no significant differences for any of the tests.

Looking at table 2 and the Swedish and Mathematics totals in grade 3, it can be seen that the difference in within-pair correlation between the twins and controls, is larger for Swedish than for Mathematics (.42 and .22 compared to .52 and .45). For different sub-tests there is, however, a considerable variation. "Reading

rate", for instance, shows a very large difference between the groups, while the results for "spelling" are much more similar. This is according to expectations, since "spelling" is specifically trained at school while "reading rate" tends to be more influenced by both genetic factors and the students' home background (Fischbein, 1979).

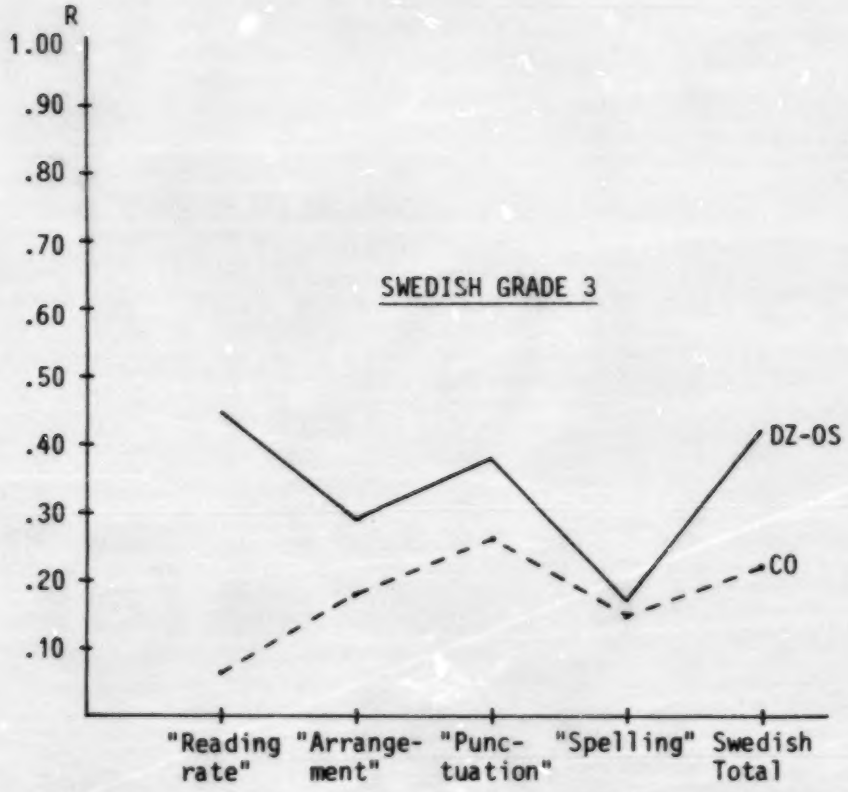

Figure 1. Intraclass correlation for achievement test results in Swedish for opposite-sex twin pairs (DZ-OS) and control pairs (CO). Grade 3.

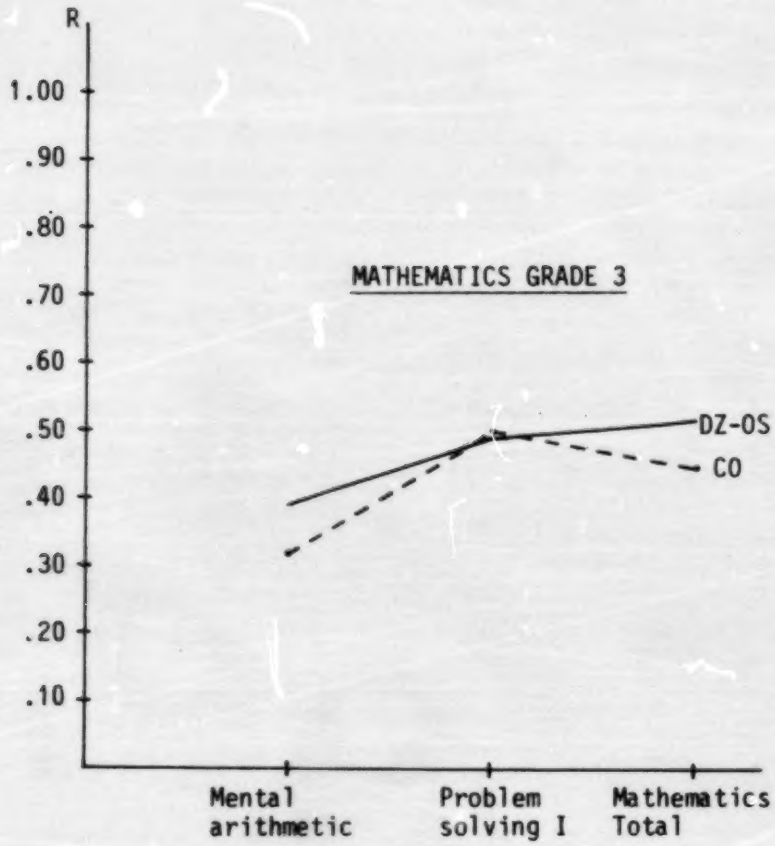

Figure 2. Intraclass correlations for achievement test results in Mathematics for DZ-OS and CO. Grade 3.

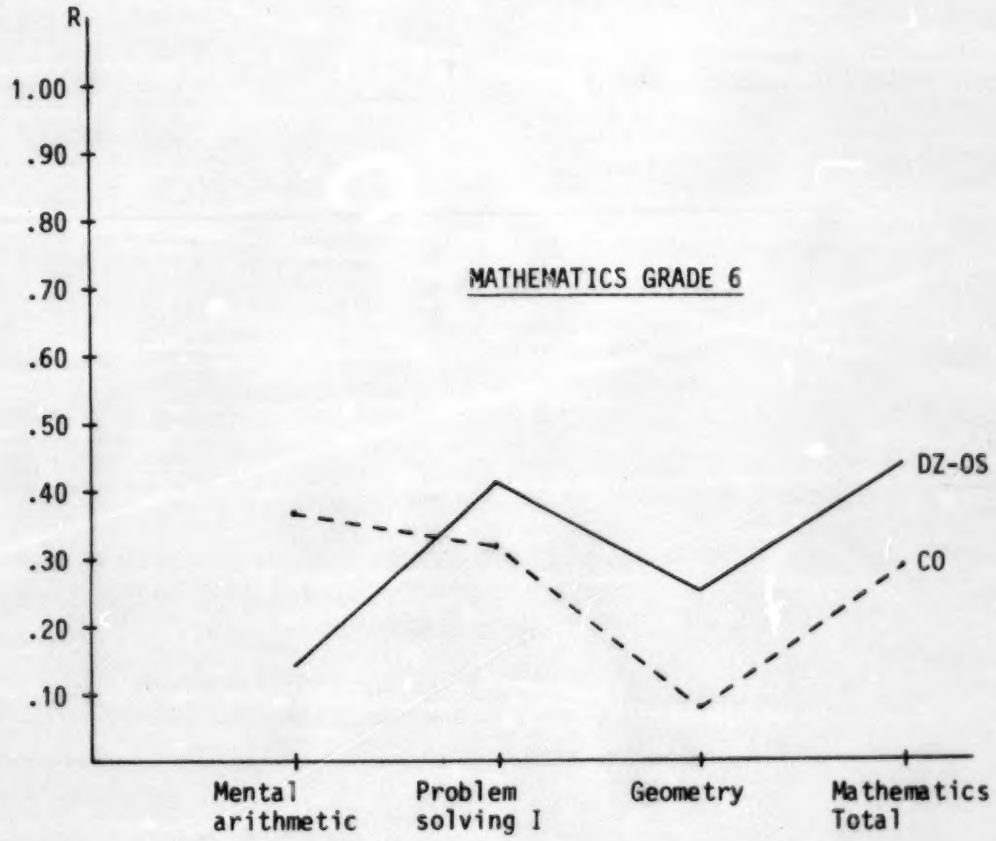

Figure 3. Intraclass correlations for achievement test results in Mathematics for DZ-OS and CO. Grade 6.

Figures 1-3 illustrate the intraclass correlations for different types of tests and for the twins and controls presented in table 2. From these diagrams it can also be seen that the smallest differences between the two groups are for spelling in Swedish and problem solving I in Mathematics. This seems to imply that the sex difference found for these types of tests mainly depends upon the sex differentatiton generally and the type of training experienced at school. It does not seem thus, as if the twins shared inheritance and home background make them more similar in these respects. The largest difference between the twins and controls, on the other hand, seems to be for "reading rate" and the total Swedish score, where the twins show a considerably smaller within-pair difference than the controls.

The general trend from grade 3 to grade 6 is for intraclass correlations to decrease in magnitude. This is true for all tests except the control group results for "mental arithmetic", where the similarity within pairs is practically the same in grade 3 and grade 6.

Figure 4 illustrates the within-pair similarity for twins and controls for the mathematics tests taken in both grade 3 and 6 as well as for the Mathematics total.

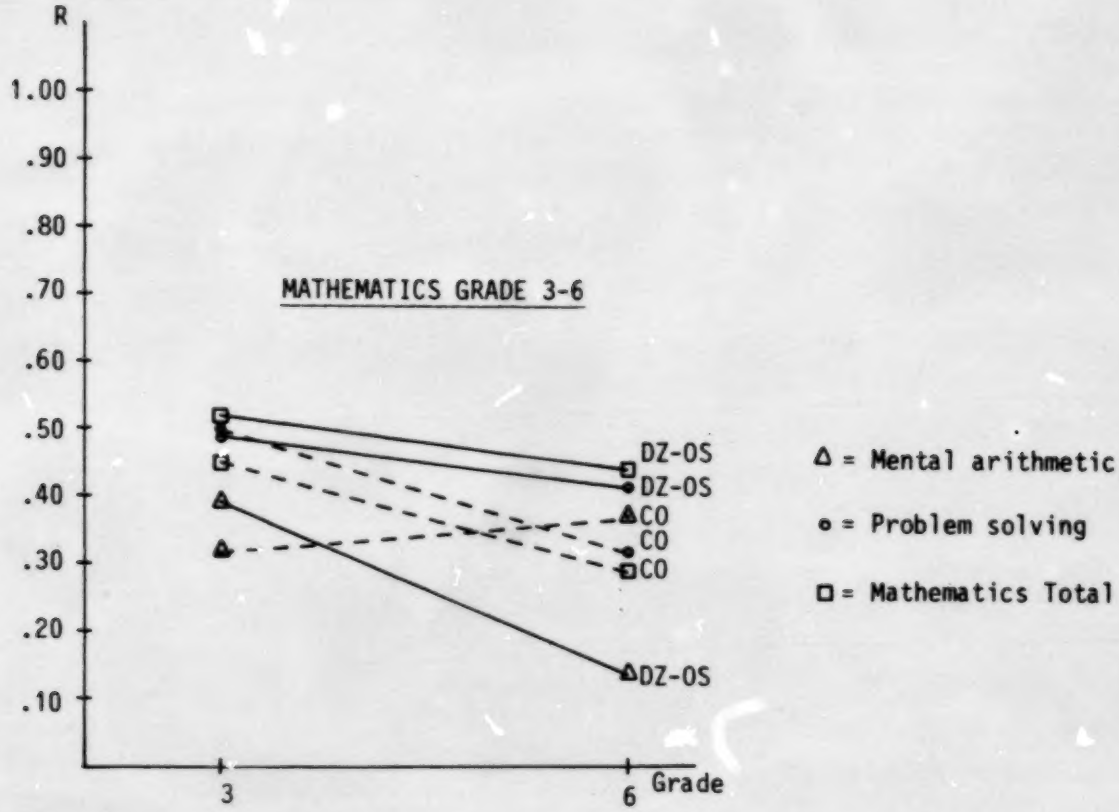

Figure 4. Intraclass correlations for achievement test results in Mathematics for DZ-OS twins and CO. Grade 3 and 6.

The mathematics education experienced at school does not seem to make either the twins or the controls more similar in test results. It is also evident from the diagram in figure 4 that the differences between the groups in within-pair similarity for mathematics test results generally are rather small and negligible in both grade 3 and 6. The only exception is for "mental arithmetic", where the twin and control pairs show reversed trends from grade 3 to 6 so that the twins tend to become less similar and the controls more similar. Generally, then, opposite-sex twin pairs do not seem to be more similar in mathematics test results than boy-girl control pairs attending the same classes.

Discussion

The results presented for male and female twins and controls in the SLU-project show significant sex differences in both Swedish and Mathematics achievement. Practically are the Swedish tests show an advantage for the girls, while only "mental arithmetic" shows an advantage for the boys in grade 3. According to expectations, however, differences in mathematics achievement between boys and girls increase from grade 3 to 6. Only numerical operations and a deductive type of problem solving test show no significant sex differences in grade 6. The magnitude of the sex differences thus seems to be related to both the *content* of the tests and the *age* of the respondents, which was to be expected on the basis of earlier studies of sex differences in achievement.

The within-pair comparisons for opposite-sex twins and boy-girl controls suggest that sex differences in Mathematics are more "educationally influenced" than in Swedish. All the swedish tests except spelling show the twins to be much more similar than the controls, while the difference is smaller and even reversed for some of the mathematics tests. This result is in agreement with earlier twin studies (Fischbein, 1979; Plomin & De Fries, 1979).

The comparison of within-pair results for twins and controls in grade 3 and 6 shows the expected trend of increasing within-pair differences for practically all the tests. This has also been found for dizygotic twins of the same sex (Fischbein, 1979; Ljung, 1965). The results also imply that the increasing sex differences between grades are not primarily due to hereditary or home background influences, since within-pair similarity seems to be of the same magnitude for the controls as for the twins (Ljung, op.cit.). Instead a plausible explanation would be an interaction of biological factors, accentuating their effects at puberty, and a differential educational treatment experienced by boys and girls at school.

Perhaps the most spectacular result found in this study is the differential effect of biological and environmental interaction on sex differences of approximately the same magnitude. Consider for instance test results for "reading achievement" and "mental arithmetic". Both show a significant sex difference with an advantage for the girls on the former test and for boys on the latter. The comparison of opposite-sex twins and boy-girl controls show quite different results, however. In "reading achievement" the twin pairs are much more similar than the control pairs, while this is not the case for "mental arithmetic". This indicates that more complex interaction models than hitherto has been devised, will be necessary to explain the type of sex-related differences presented here (Lips & Colwill, 1979; Jacklin, 1978; Parsons, 1980).

A comparison of ability test results for opposite-sex twins and controls also indicate large differences depending on type of test (Fischbein, 1981). Perhaps it is not a coincidence that the test showing the largest sex difference in favour of the girls "the clerical speed test", also demonstrates the largest difference between twins and controls. For this test as well as for "reading rate" the twin pairs tend to be considerably more similar than the control pairs in test results. Are in fact sex differences favouring girls more related to hereditary-environment influences connected with family background, while differences favouring boys are more related to biological sex typing in combination with training experiences? Such an explanation would be consistent with the decreasing differences between boys and girls in "female subjects" such as reading and writing, and increasing differences in "male subjects" such as mathematics through the school years.

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Abstract

Biosocial influences on sex differences, found for school achievement test results in grades 3 and 6, have been studied by means of opposite-sex twin pairs and singleton controls, attending the same classes as the twins.

As expected the opposite-sex twin pairs tend to be more similar in achievement test results in Swedish and Mathematics than their controls. This is, however, more pronounced for Swedish and could probably be due to Mathematics being more susceptible to the type of training experienced at school, while achievement in the Swedish subject is more dependent upon both home background and heredity-environment interaction.

Both the twins and their controls tend to become less similar within pairs in achievement test results from grade 3 to 6. It does *not* seem, thus, as if the educational impact experienced by twins or non-twins, attending the same classes, will make them more similar in this respect. It is also evident that the increasing sex differentiation between grades is *not* primarily due to home background influences, but rather can be explained both by differential educational treatment and differentiation of abilities with increasing age.